RESEARCHES ON THE SEX-CHROMOSOMES OF PSYCHIDÆ (LEPIDOPTERA).

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WITH ONE TEXT-FIGURE AND ONE PLATE.

The demonstration which I have given of the digametic condition of the female sex in Lepidoptera in the case of *Phragmatobia*,[1] gave a brilliant confirmation of the assumption made by genetic experimenters (Doncaster, Goldschmidt) that in butterflies the female sex must be digametic. In all other cases the digametic condition has been conclusively demonstrated only in the male, and as was to be expected, therefore, my results were doubted. For this reason I sought for a typical case in which the distribution of the sex-chromosomes could readily be demonstrated, and to work it out in such a manner as to leave no room for further doubt.

Such a typical case was found in certain species of Psychidæ. I was led to examine this group because the sex-ratios (which under certain conditions are quite atypical) gave reason to look for interesting cytological conditions; for it might be expected that in the parthenogenetic species, as is the case in *Angiostomum*, *Phylloxera*, etc., the preponderance or exclusive appearance of only one sex might be determined by the sex-chromosome mechanism. Unfortunately this point could not be demonstrated; on the other hand, the diœcious forms, *Talæporia tubulosa* and *Fumea casta*, were found to offer material suitable for my main purpose.

1. *Talæporia tubulosa* RETZ.

(*a*) *Maturation of the Egg*.—As the daughter-chromosomes of the first maturation-division separate, one chromosome remains at the middle of the spindle without showing at first any indication as to whether it will pass to the inner or the outer pole (Figs. 1–3). In Fig. 3 it will probably pass inwards, as may be

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inferred from its relation to the slightly developed spindle-thickening. As the daughter-chromosomes move towards the spindle-poles the X-chromosome is found to lag behind, in some cases towards the outer plate, in others towards the inner. In Fig. 4 it is seen wandering inwards, in 5 outwards, in 6 and 7 inwards, in 8 outwards. During the interkinesis it is only occasionally recognizable (Fig. 9). In the metaphase of the second division (Fig. 10) it has without exception overtaken the autosomes and thenceforwards shows precisely the behavior of an autosome. Only in exceptional cases does the X-chromosome move from the beginning at the same rate with the autosomes; in such cases, of course, it is not distinguishable in side-views of the spindle.

In the Psychidæ, as in other cases (see Seiler, '14), chromatin is in some instances eliminated in large quantities during the first maturation-division, in others not at all.

The equatorial plate of the first maturation-division in the egg possesses 30 chromosomes, of which 29 are bivalent and one univalent. As is to be expected, the daughter-plates have different numbers of chromosomes. If the outer plate has 30 chromosomes the inner has 29, and *vice versa.* I have tried to obtain photographic proof of this, but the task is extremely difficult and tedious. Each egg contains but one spindle, and this must be so cut that the knife passes between the two daughter-plates without injuring them. Further, all the chromosomes (of course in both plates) must lie exactly in one plane and at right angles to the optical axis. Fig. 18 shows such an ideal plate with 29 chromosomes, and this photograph alone reproduces the size-relations of the chromosomes exactly as in nature. The sister-plate is not suitable for photographing. *All the plates photographed for this work are in themselves quite as clear and demonstrative* as Fig. 18. Since, however, the chromosomes did not always lie in the same plane, it was necessary to turn the fine adjustment somewhat during the exposure; hence the somewhat defective and in part ambiguous character of the figures. Figs. 11 and 12 are two sister-plates (in each case the first number designates the outer plate, the second number the inner), in the anaphase of the first division. Since the chromosomes undergo little or no change of relative position during the separation

of the daughter-plates, the homologous pairs can be identified with considerable certainty. In Figs. 13 and 14, again showing two sister-plates, the X-chromosome lies centrally.

Table I., which follows, gives a summary of selected cases in which both daughter-plates lie entirely in the same section, and which in other respects fulfill all the conditions of demonstrative clearness. Table II. summarizes the number of observed cases in which the X-chromosome as seen in lateral views of the spindle, is passing towards the outer or the inner pole. The result permits us to predict the primary sex-ratio to be expected in *Talæporia*. Those X-chromosomes that pass outwards enter the polar body, those that pass inwards divide equally in the second maturation-division and enter the female pro-nucleus.

TABLE I.

Locality.	No.	No. of Preparation.	No. of Chromosomes.	
			Outer Plate.	Inner Plate.
Breslau	1	1.14	30	29
"	2	1.10	29	30
"	3	26.6	30	
"	4	51.2	30	
Tornow	5	122.5	30	29
"	6	125.9	29	
"	7	136.4	30	29
"	8	136.1		30
"	9	136.9		29
"	10	136.10	29	
"	11	136.13	29	
"	12	136.17	29	30
"	13	137.3	30	29
"	14	138.5	30	29
"	15	138.7		29
"	16	138.8	29	
"	17	138.12		30
"	18	138.11		29
"	19	138.16	30	
"	20	139.11		29
"	21	139.13		29
"	22	140.6	29	30
"	23	140.10	29	
"	24	140.5	29	
"	25	149.7	29	30
"	26	150.20	30	
"	27	151.2		30
"	28	151.3	29	30
"	29	152.2	30	29
"	30	153.14	30	
"	31	153.16		30
"	32	155.1	30	
"	33	6.11	29	29
"	34	140.18	29	29

(*b*) *Maturation of the Sperm.*—In the spermatogenesis no sex-chromosomes can be distinguished. The equatorial plates of the first maturation-division show 30 chromosomes (Figs. 26, 27) and those of the second division the same (Fig. 28).

TABLE II.

Locality.	The X-Chromosome Passes		Total.	Sex Ratio.	
	Outwards.	Inwards.		Female.	Male.
Breslau........	73	44	117	1.66	1
Tornow........	61	45	106	1.35	1
	134	89	223	1.50	1

(*c*) *The Somatic Chromosome-number.*—Since two classes of eggs are formed, having respectively 29 and 30 chromosomes, we may expect to find two kinds of embryos, one having 59 chromosomes, the other 60. The actual conditions correspond with this expectation. In the stage of blastoderm-formation it is possible to count the somatic chromosome-number with absolute certainty. Figs. 15 and 16 show 60 chromosomes, though not so clearly as the actual object. Table III. gives a summary of the observed cases. Only such embryos were recorded as showed at least 2 (often 4 to 6) perfectly clear equatorial plates, each of which lay entirely in a single section and in the middle of its thickness, and in which no doubt could exist concerning the limits of a single chromosome.

TABLE III.

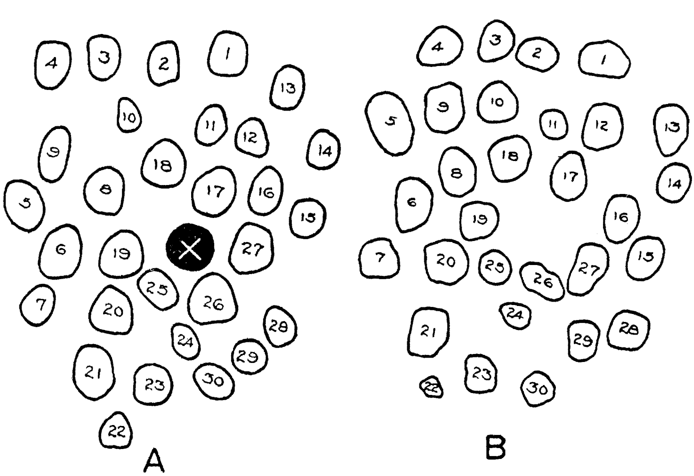
Locality.	No. of Embryos.	Chromosomes.
Tornow....................	30	59
"	25	60
"	4	58

As the table shows, a third sort of embryo could be demonstrated possessing 58 chromosomes. This determination can not possibly rest on an error, for in the first embryo seven perfectly clear plates all showed 58 chromosomes, in the second 6, in the third 5, and in fourth 2. Such embryos would probably produce but one kind of egg, containing 29 chromosomes. In

point of fact, I have two perfect pairs of daughter-plates, each with 29 chromosomes (see Table I., nos. 33, 34). No X-chromosome is present in these cases. If we leave these out of account there remain 35 females and 25 males, a sex-ratio of 1.36: 1 in favor of the female, that is to say, exactly the ratio to be expected from observations on the maturation-phenomena in the Tornow race. Possibly the embryos with 58 chromosomes may have arisen by the development of unfertilized eggs.

2. *Fumea casta* Pall.

The equatorial plate of the first maturation-division in the egg shows 31 chromosomes. One of these must be univalent, for the daughter-plates show in some cases 31 chromosomes, in others 30. As in *Talæporia*, an X-chromosome is present but strange to say it fails to lag behind the autosomes and passes together with them to one spindle-pole. Fig. 23, from a perfect plate with 30 chromosomes, clearly shows the natural size-relations. Figs. 19 and 20, 21 and 22, 24 and 25 are three pairs of daughter-plates, from the interkinesis, in which the chromosomes are perfectly clear and well-separated; but unfortunately the plates lay obliquely, so that the photographs seem to show certain fusions which do not really exist. Text-figure 1 shows the same



Text Fig. 1.

plates as Photos. 19–20, reproduced as accurately as possible in respect to the size-relations and relative positions, with an attempt to identify the homologous chromosomes. The X-chromosome happens, quite by accident, to be in all three cases in the outer plate; quite as often it is found in the inner one.

The embryos have either 61 or 62 chromosomes.

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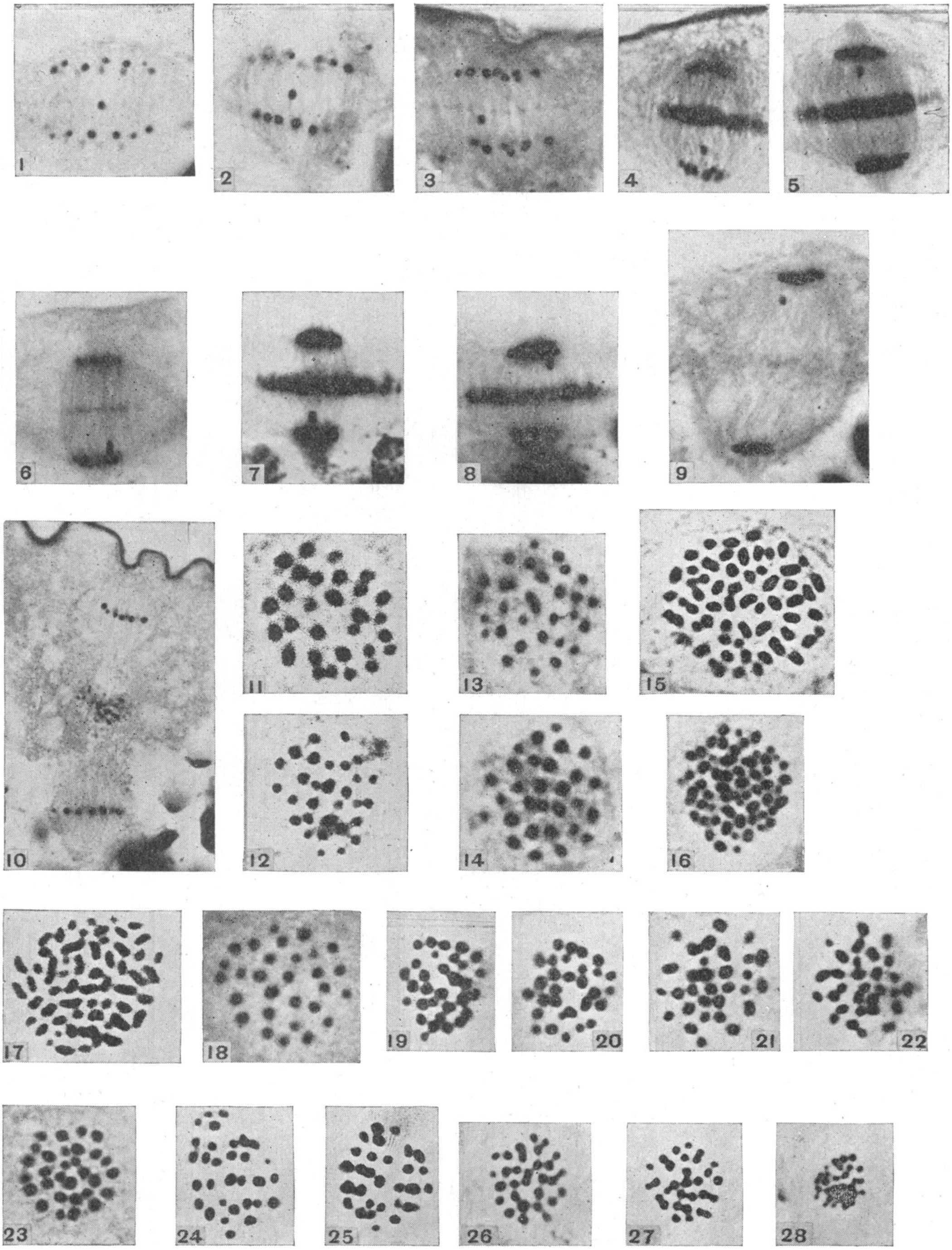
EXPLANATION OF PLATE.

None of the photographs retouched. Enlargement 2,000, excepting Fig. 10, which is 1,000.



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